

## **General Disclaimer**

### **One or more of the Following Statements may affect this Document**

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

(NASA-TM-78462) TOXICITY OF MATERIALS IN  
FIRE SITUATIONS: LABORATORY DATA OBTAINED  
AT THE UNIVERSITY OF SAN FRANCISCO (NASA)  
27 p HC A03/MF A01

CSCL 07C

N78-15172

Unclas  
01835

G3/23

---

# **Toxicity of Materials in Fire Situations: Laboratory Data Obtained at the University of San Francisco**

---

Carlos J. Hilado, Colleen J. Casey,  
Demetrius A. Kourtides, and John A. Parker  
December 1977

---



National Aeronautics and  
Space Administration

**Ames Research Center**  
Moffett Field, California 94035



NASA TECHNICAL MEMORANDUM

NASA TM-78,462

TOXICITY OF MATERIALS IN FIRE SITUATIONS:

LABORATORY DATA OBTAINED AT THE UNIVERSITY OF SAN FRANCISCO

Carlos J. Hilado and Colleen J. Casey  
Fire Safety Center, Institute of Chemical Biology  
University of San Francisco  
San Francisco, California 94117

and

Demetrius A. Kourtides and John A. Parker  
Chemical Research Projects Office  
Ames Research Center  
Moffett Field, California 94035

December 1977

TOXICITY OF MATERIALS IN FIRE SITUATIONS:  
LABORATORY DATA OBTAINED AT THE UNIVERSITY OF SAN FRANCISCO

Carlos J. Hilado and Colleen J. Casey  
University of San Francisco

and

Demetrius A. Kourtides and John A. Parker  
Ames Research Center

ABSTRACT

Toxicity test data on materials evaluated at the University of San Francisco are presented. Approximately 300 materials have been evaluated using a specific set of test conditions. Data obtained using ten different sets of test conditions are presented.

INTRODUCTION

Earlier compilations of toxicity data on materials evaluated at the University of San Francisco have listed test results on about 270 materials using a specific set of test conditions (1-3). Subsequent work has increased the number of materials evaluated using some sets of test conditions, and the number of replicate tests of some materials. This paper presents an up-to-date compilation of the data obtained.

METHODS

The USF screening test method has been described in other publications which contain the details of the apparatus and procedure (4-6). The test conditions at which materials have been evaluated are:

- A. 200-600°C rising temperature, 40°C/min, no forced air flow
- B. 200-800°C rising temperature, 40°C/min, no forced air flow
- C. 200-800°C rising temperature, 40°C/min, 16 ml/sec air flow
- D. 200-800°C rising temperature, 40°C/min, 48 ml/sec air flow
- E. 600°C fixed temperature, no forced air flow
- F. 800°C fixed temperature, no forced air flow
- G. 800°C fixed temperature, 16 ml/sec air flow
- H. 800°C fixed temperature, 48 ml/sec air flow
- I. 600°C fixed temperature, 16 ml/sec air flow
- J. 800°C fixed temperature, 48 ml/sec air flow



## DATA

Relative toxicity data on the materials evaluated using these test conditions are presented in Tables 1 to 10.

<u>Test Conditions</u>	<u>Table</u>	<u>Number of Materials</u>
A. 600°C rising, no air	9	16
B. 800°C rising, no air	1	270
C. 800°C rising, 16 ml/sec	10	3
D. 800°C rising, 48 ml/sec	2	19
F. 800°C fixed, no air	3	18
G. 800°C fixed, 16 ml/sec	4	16
H. 800°C fixed, 48 ml/sec	5	17
E. 600°C fixed, no air	6	15
I. 600°C fixed, 16 ml/sec	7	15
J. 600°C fixed, 48 ml/sec	8	15

The values given are mean  $\pm$  standard deviation between tests. The data are arranged in order of increasing time to death, or decreasing toxicity under the specific test conditions. The authors consider time to death to be a more precise measurement because it is less dependent on individual alertness and subjective judgement, and is based on all four animals in a test rather than on the first animal to exhibit incapacitation. These tables are listings rather than rankings, because the standard deviation assignable to each value requires the observed difference between any two values to be a certain magnitude before that difference can be considered statistically significant.

The data in Table 1 cover 270 materials and represent the principal data base for determining the effect of changes in test conditions and the effect of chemical composition. Replicate tests were performed on almost all materials. Insufficient sample limited a few materials to a single test. From 6 to 17 tests have been performed on reference materials.

Relative toxicity data on materials by generic type, based on the data in Table 1, are presented in Tables 11 and 12. These tables are limited to generic materials which were represented by at least two samples. The values given are mean  $\pm$  standard deviation between samples; with individual values in these tables being based on as many as 81 tests and 324 animals, any other standard deviation becomes difficult to manage.

Table 11 presents data on 16 synthetic polymers by generic type, with data on wood and cellulosic board included for comparison purposes. Polyurethane flexible foam with 29 samples had the most extensive representation.

Table 12 presents data on 8 generic types of fibers and fabrics. Cotton and rayon with 10 samples each had the most extensive representation. Materials known to contain fire retardant are not included in these averages, with the sole exception of fire-retardant-treated 100% cotton fibers and fabrics. Data on 10 types of fabric blends each consisting of two principal generic types are also presented, to provide an indication of any synergistic effects.

## DISCUSSION

The wide range of performance observed with different samples of a generic material emphasizes the inadvisability of considering a specific level of performance as typical or representative of a generic material. The variation can be particularly pronounced in the case of generic materials which provide considerable flexibility in formulation, or contain varying levels of fire retardants to meet the requirements of different markets.

Comparisons between generic groups with the purpose of identifying differences due to chemical composition should therefore be made with the often considerable overlap between generic groups in mind.

Among the synthetic polymers, the sulfur-containing polymers seemed to exhibit the shortest times to death, and some chlorine-containing polymers tended to exhibit the longest times to death. Polyvinyl chloride and chlorinated polyvinyl chloride gave the shortest times to incapacitation; polystyrene and polycarbonate gave the longest times to incapacitation.

When the synthetic polymers are compared with wood on a generic basis, only the sulfur-containing polymers would appear to be more toxic than wood on the basis of time to death, and only chlorinated polyvinyl chloride would appear to be more toxic than wood on the basis of time to incapacitation.

Among the fibers and fabric, wool, silk, and polyester exhibited the shortest times to incapacitation and times to death. Polypropylene and nylon exhibited the longest times to death, and nylon and aromatic polyamide exhibited the longest times to incapacitation. Fire retardant treatment seemed to render 100% cotton fabrics less toxic on the average, but the difference was not statistically significant.

Strict comparisons between generic types of materials should be made with particular caution in the case of fabrics, because the presence of backcoatings may be a compounding factor. It could be argued that if a particular material requires backcoating to render it commercially acceptable, that backcoating becomes an inherent part of the commercial material.

Evaluation of the performance of blends of two generic types of fabrics relative to the two types of fabrics taken separately, showed that the performance of the blends did not differ significantly from that expected from simple linear interpolation between the two generic types. There is therefore no evidence of synergism under these particular test conditions. Cotton/polyester blends containing 59 to 70 per cent cotton may be the only possible exception; these blends exhibited less toxicity than either 100% polyester or 100% cotton.



Comparisons between data in the various tables to determine the effect of changes in test conditions should be made with the standard deviations in mind. In many cases, apparent differences are not statistically significant.

Times to incapacitation and times to death generally decreased when changing from a rising temperature program to a fixed temperature program, and when changing from no forced air flow to 16 ml/sec air flow. Relative rankings tended to remain the same with changes in test conditions, but some reversals were observed.



## CONCLUSIONS

The materials evaluated under these test conditions exhibited a broad range of relative toxicity performance, even among materials of the same generic type. This variation emphasizes the need to evaluate each sample of material as an individual candidate for the application involved.

The relative rankings of materials tended to remain the same in spite of changes in test conditions. Some significant reversals in rankings, however, were observed. Materials should therefore be compared under test conditions which show some relevance to the intended application.

## ACKNOWLEDGEMENTS

This work was performed at the Fire Safety Center of the University of San Francisco, with the support of the National Aeronautics and Space Administration under NASA Grant NSG-2039.

The authors are indebted to Dr. Arthur Furst and Dr. Henry A. Leon for their assistance and advice.

Table 1. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incubation		
modacrylic/nylon 70/30 fabric	4.54 + 1.00	3.74 + 0.23	2	8
wool/spandex 99/1 fabric	5.80 + 0.42	4.52 + 0.13	2	8
wool fabric, 100%, 2	6.47 + 0.23	5.06 + 0.69	2	8
nylon fabric, 20/80 polyurethane foam/acrylic back	6.72 + 0.73	5.55 + 0.47	2	8
wool fiber, washed	7.06 + 1.18	4.82 + 1.01	2	8
feathers/down 75/25	7.25 + 0.12	5.12 + 0.36	2	8
wool/nylon 90/10 fabric	7.53 + 1.36	5.08 + 0.60	3	12
wool fabric, 100%, 1	7.60 + 2.90	5.45 + 1.77	4	16
rubberized hair, FR	7.62 + 0.83	4.42 + 0.36	2	8
rubberized hair	8.18 + 0.50	5.82 + 0.28	2	8
wool fabric, 100%, treated	8.24 + 1.84	6.28 + 1.45	4	16
wool/nylon 88/12 fabric	8.92 + 3.13	5.06 + 1.58	3	12
wool/nylon 86/14 fabric	8.93 + 1.06	5.34 + 0.83	2	8
silk fabric, 100%	8.94 + 0.01	5.84 + 0.12	2	8
polyurethane flexible foam, 1.75 pcf, E3	9.14 + 0.25	7.50 + 0.67	2	8
polyester fabric, 100%	9.36 + 0.45	7.38 + 0.18	2	8
silk fabric, 100%	9.43 + 1.64	7.56 + 1.64	2	8
polyester batting, without resin	9.44 + 0.76	8.21 + 0.44	2	8
wool fabric, 100%, reference	9.46 + 1.59	5.92 + 1.46	2	8
cotton batting, 2	9.66 + 1.29	5.90 + 0.04	2	8
polyurethane flexible foam, 1.45 pcf, E2	9.86 + 0.92	8.30 + 0.25	2	8
wool/nylon 85.4/14.6 fabric	10.05 + 1.39	7.26 + 1.75	2	8
rayon/cotton 75/25 fabric	10.06 + 0.81	7.23 + 0.78	2	8
polyurethane flexible foam, 1.20 pcf, E1	10.06 + 0.28	8.90 + 0.53	2	8
rayon/cotton 61/39 fabric	10.12 + 1.89	8.02 + 0.70	2	8
polyester batting, 13.3% acrylic resin	10.15 + 0.64	8.55 + 0.52	2	8
polyurethane flexible foam, 1.80 pcf, D1	10.16 + 0.68	8.45 + 0.40	3	12
cotton batting, 1	10.16 + 0.43	6.74 + 0.90	2	8
leather	10.22 + 1.72	8.16 + 0.69	2	8
polyether sulfone, 300-P	10.26 + 0.32	9.63	1	4

values given are mean ± standard deviation

Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
rayon/cotton 75/25 fabric	10.23 + 0.81	7.40 + 1.09	2	8
cotton batting, FR	10.44 + 0.95	7.93 + 1.20	2	8
polyester batting, 20.6% acrylic resin	10.54 + 1.28	8.90 + 0.89	2	8
polyphenylene sulfide, 3	10.57 + 1.40	9.59 + 1.30	4	16
polyurethane rigid foam, 10% FR, R2	10.62 + 1.10	8.28 + 1.39	2	8
polyester/acetate 65/35 fabric	10.63 + 0.20	7.76 + 0.11	2	8
polyester/acetate 65/35 fabric	10.65 + 0.14	7.40 + 0.61	3	12
rayon/cotton 64/36 fabric	10.78 + 1.72	7.99 + 0.75	3	12
hemlock, untreated	10.80 + 0.18	7.28 + 2.03	2	8
cotton/acetate/nylon/polyester 55/23/19/3 fabric	10.84 + 0.35	7.83 + 0.74	3	12
hardboard, unfinished	10.86 + 0.54	8.56 + 0.37	2	8
rayon/cotton/nylon 63/27/10 fabric	10.91 + 0.65	8.31 + 0.15	2	8
cotton/nylon 73/27 fabric	10.94 + 0.94	7.88 + 0.09	2	8
polyimide foam, modified	11.02 + 0.62	9.04 + 0.47	2	8
polyphenylene sulfide, 1	11.07 + 1.55	10.22 + 1.80	2	8
polybismaleimide	11.12 + 0.11	9.60 + 0.14	2	8
polyurethane flexible foam, FR, 1.80 pcf, D2	11.18 + 0.74	9.20 + 0.97	3	12
cotton batting, FR, 8% boric acid	11.20 + 1.25	8.21 + 0.05	2	8
polyaryl sulfone, 1	11.23 + 1.48	10.01 + 1.35	3	12
rayon/cotton/acetate/nylon 43/25/23/9 fabric	11.37 + 0.35	6.65 + 2.39	2	8
rayon/cotton/acetate/polyester 73/16/6/5 fabric	11.40 + 0.92	9.10 + 0.38	2	8
rayon/cotton 59/41 fabric	11.47 + 1.12	7.92 + 2.13	2	8
red oak, 2	11.50 + 0.71	9.09 + 1.00	2	8
rayon/cotton 68/32 fabric	11.57 + 0.31	5.68 + 0.21	2	8
polyurethane flexible foam, 12% FR, 1.45 pcf, E5	11.73 + 0.03	9.13 + 1.24	2	8
rayon/cotton 64/36 fabric	11.75 + 2.51	8.46 + 1.57	2	8
particle board, untreated	11.82 + 0.04	9.32 + 0.39	2	8
cotton/nylon 82/18 fabric	11.89 + 0.95	8.46 + 0.94	2	8
cotton fabric, 100%	11.90 + 1.63	7.10 + 0.14	2	8
silk/nylon 70/30 fabric	11.92 + 0.14	8.95 + 0.66	2	8

values given are mean + standard deviation



Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
cotton/rayon 63/37 fabric	11.94 + 3.61	6.30 + 2.75	2	8
cotton/rayon 53/47 fabric	11.96 + 0.38	8.33 + 1.76	2	8
polyurethane flexible foam, 12% FR, 1.40 pcf, F1	12.03 + 1.29	10.25 + 1.64	4	16
rayon/cotton/nylon 41/36/23 fabric	12.09 + 1.90	9.34 + 1.23	2	8
cotton/nylon 86/14 fabric	12.11 + 2.07	9.61 + 1.46	2	8
rayon/acetate/olefin 62/19/19 fabric	12.14 + 1.06	7.71 + 0.13	2	8
polyether sulfone, 212-P	12.22 + 1.52	10.72 + 1.74	4	16
rayon/cotton/acetate/polyester 66/19/11/4 fabric	12.22 + 0.91	6.86 + 0.65	2	8
rayon fabric, 100%	12.31 + 1.21	9.34 + 0.55	2	8
cotton/acetate/nylon/nylon 61/25/11/3	12.37 + 0.81	8.37 + 0.81	2	8
rayon fabric, 100%	12.39 + 0.14	7.93 + 1.86	2	8
polyphenylene sulfide, 2	12.40 + 1.86	10.84 + 1.89	2	8
rayon/cotton 73/27 fabric	12.43 + 1.67	8.41 + 0.48	2	8
rayon/olefin 73/27 fabric	12.55 + 2.11	9.50 + 0.11	2	8
polyurethane flexible foam, 12% FR, 1.75 pcf, E6	12.57 + 0.01	9.66 + 1.33	2	8
sisal	12.59 + 3.41	6.43 + 2.05	2	8
rayon/nylon 56/44 fabric	12.62 + 2.82	8.98 + 2.17	2	8
rayon/acetate/cotton 31.49/26.80/41.71 fabric	12.62 + 2.54	7.46 + 0.75	2	8
silk/nylon 70/30 fabric	12.74 + 1.15	8.94 + 0.43	2	8
pigskin	12.78 + 0.77	7.15 + 0.71	2	8
rayon fabric, 100%	12.79 + 1.32	8.48 + 1.37	2	8
nylon fabric, 100%	12.81 + 0.94	9.40 + 2.85	2	8
cotton/acetate 67/33 fabric	12.90 + 1.83	10.26 + 2.45	2	8
rayon/cotton/acetate/nylon 57/23/11/9	12.96 + 1.64	10.47 + 0.17	2	8
polypropylene fabric, 100%	12.98 + 0.52	10.75 + 0.18	2	8
polyurethane flexible foam, 12% FR, 2.80 pcf, F5	13.01 + 2.09	11.03 + 2.00	4	16
polyurethane flexible foam, HR, FR, 2.80 pcf, H6	13.01 + 0.11	10.32 + 0.44	3	12
cotton fabric, 100%	13.02 + 0.93	8.54 + 0.53	2	8
polyurethane flexible foam, 12% FR, 1.45 pcf, F2	13.02 + 0.89	11.20 + 0.84	4	16
cotton fabric, FR, 2	13.06 + 1.46	9.78 + 2.55	2	8

values given are mean + standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY



Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
cotton, surgical	13.13 ± 1.51	9.61 ± 1.42	17	68
nylon fabric, 100%	13.14 ± 0.49	10.65 ± 0.10	2	8
cotton fabric, 100%	13.21 ± 1.37	10.48 ± 0.08	2	8
rayon/nylon/cotton 49/33/18 fabric	13.28 ± 1.70	9.28 ± 0.31	3	12
nylon 6/10	13.28 ± 1.63	11.48 ± 1.59	2	8
polyester fabric, 100%	13.30 ± 1.95	8.85 ± 3.25	2	8
polyurethane flexible foam, HR, FR, 2.70 pcf, H1	13.32 ± 0.95	10.74 ± 1.16	3	12
nylon 6	13.47 ± 1.13	11.55 ± 0.66	3	12
nylon fabric, 100%	13.48 ± 0.72	10.87 ± 0.70	2	8
aromatic polyamide fabric, 1	13.50 ± 0.98	11.79 ± 1.71	2	8
polyurethane flexible foam, HR, FR, 2.60 pcf, H5	13.51 ± 1.29	10.27 ± 0.61	3	12
polyurethane flexible foam, 12% FR, 2.50 pcf, F4	13.56 ± 4.57	10.50 ± 2.20	4	16
Douglas fir, 2	13.62 ± 0.63	9.84 ± 0.12	2	8
polyester foam	13.66 ± 0.67	7.50 ± 0.88	2	8
cotton fabric, 100%	13.67 ± 3.16	8.69 ± 0.19	2	8
polyurethane rigid foam, 7% FR, R3	13.69 ± 1.44	10.91 ± 1.51	3	12
polyisocyanurate rigid foam	13.74 ± 0.90		2	8
polyurethane flexible foam, 12% FR, 1.20 pcf, E4	13.74 ± 0.61	9.56 ± 2.57	2	8
polyester/nylon 54/46 fabric	13.75 ± 0.99	8.89 ± 2.74	2	8
polyurethane flexible foam, HR, FR, 2.20 pcf, H4	13.79 ± 0.74	10.87 ± 1.34	3	12
beech	13.82 ± 1.69	9.69 ± 0.84	3	12
cotton/nylon 59/41	13.86 ± 0.72	9.51 ± 0.12	2	8
polyurethane flexible foam, 12% FR, 2.00 pcf, F3	13.92 ± 1.06	11.41 ± 1.27	6	24
rayon fabric, 100%	13.98 ± 2.92	10.06 ± 1.32	2	8
polyethylene, 1	13.99 ± 0.85	11.54 ± 0.62	3	12
polyurethane rigid foam, FR, Q1	14.05 ± 0.60	11.23 ± 0.50	3	12
aspen poplar	14.06 ± 1.83	9.96 ± 1.66	3	12
polyurethane rigid foam, R1	14.10 ± 0.74	9.64 ± 2.31	2	8
rayon/cotton/nylon/polyester 54/24/16/6 fabric	14.12 ± 2.60	8.30 ± 0.67	2	8
acetate/polyester 81/19 fabric, FR	14.14 ± 3.89	6.14 ± 2.57	2	8

values given are mean ± standard deviation

Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
nylon/vinyon 70/30 fabric	14.15 ± 1.68	10.85 ± 1.63	2	8
cotton/rayon/acetate 50/30/20 fabric	14.22 ± 3.23	8.50 ± 0.33	2	8
acetate/nylon/cotton/polyester 48/28/15/9 fabric	14.22 ± 3.07	10.02 ± 0.79	2	8
cotton fabric, 100%	14.22 ± 2.14	8.94 ± 1.17	2	8
rayon/nylon/cotton 52/33/15 fabric	14.23 ± 0.68	9.46 ± 0.05	2	8
cotton/polyester 50/50 fabric	14.27 ± 0.17	9.18 ± 1.49	3	12
western hemlock	14.37 ± 1.52	9.99 ± 0.40	3	12
cotton/nylon/acetate 55/39/6 fabric	14.41 ± 5.04	9.53 ± 3.50	2	8
rayon/acetate/cotton 49/26/25 fabric	14.41 ± 3.00	10.38 ± 0.58	2	8
polyether sulfone, 200-P	14.42 ± 2.34	13.39 ± 2.28	2	8
polyurethane flexible foam, HR, 2.80 pcf, H7	14.44 ± 3.16	10.67 ± 1.59	3	12
ABS, 3	14.48 ± 1.59	10.58 ± 1.32	2	8
cotton/nylon/acetate 52/42/6 fabric	14.49 ± 2.01	9.84 ± 3.02	2	8
red oak, 1	14.50 ± 1.23	10.23 ± 0.81	3	12
polyether sulfone 300-P/glass fabric	14.54 ± 0.23	12.74 ± 0.74	2	8
cotton batting, FR, 10% boric acid	14.58 ± 1.06	9.94 ± 2.92	2	8
rayon/nylon/acetate 41/30/29 fabric	14.63 ± 4.56	10.26 ± 5.07	2	8
cotton/nylon/acetate 39/37/14/10 fabric	14.63 ± 1.37	8.44 ± 2.27	2	8
rayon/cotton 71/29 fabric	14.63 ± 1.32	7.57 ± 2.79	2	8
olefin/polyester 55/45 fabric	14.64 ± 1.72	9.14 ± 0.36	2	8
rayon/acetate/cotton 65/25/10 fabric	14.75 ± 1.68	9.55 ± 1.08	2	8
Douglas fir, 1	14.76 ± 0.90	11.79 ± 0.90	3	12
cotton/polyester 59/41 fabric	14.84 ± 1.72	9.23 ± 1.93	2	8
aromatic polyamide fabric, 2	14.89 ± 2.11	10.00 ± 0.97	2	8
western red cedar	14.91 ± 3.18	10.00 ± 0.97	3	12
polyethylene foam, 2	14.96 ± 0.23	7.81 ± 0.01	2	8
rayon/polyester 87/13 fabric	15.01 ± 2.27	6.90 ± 2.51	2	8
polyurethane flexible foam, HR, 3.00 pcf, H8	15.07 ± 2.59	9.84 ± 0.78	3	12
cotton/nylon 75/25 fabric	15.09 ± 3.31	9.27 ± 0.62	2	8
yellow birch	15.09 ± 2.57	9.56 ± 0.97	3	12

values given are mean ± standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY

Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of	
	Death	Incapacitation	Tests	Animals
cotton fabric, 100%	15.10 + 3.03	9.18 + 3.61	2	8
polysulfone	15.10 + 1.43	12.16 + 2.86	2	8
rayon fabric, 100%	15.10 + 1.33	8.87 + 2.75	2	8
polyurethane flexible foam, HR, FR, 2.02 pcf, H2	15.11 + 1.95	9.85 + 3.18	3	12
rayon/acetate/cotton 55/30/15 fabric	15.14 + 4.39	11.17 + 3.71	2	8
polyethylene foam, 1	15.14 + 1.94	8.44 + 1.94	2	8
polyurethane rigid foam, FR, 24.3 pcf	15.14 + 0.62	12.62 + 1.24	2	8
cotton fabric, FR, 1	15.31 + 2.46	8.30 + 3.41	3	12
FR vinyl/nylon 80/20 fabric	15.32 + 0.78	12.56 + 2.42	2	8
cotton/nylon/nylon 67/30/3 fabric	15.33 + 2.25	10.01 + 0.09	2	8
rayon/cotton 66/34 fabric	15.40 + 3.57	12.17 + 2.12	2	8
eastern white pine	15.42 + 0.90	10.72 + 0.85	3	12
acetate/nylon/cotton 35/33/32 fabric	15.44 + 1.46	9.92 + 0.19	2	8
polyurethane flexible foam, FR, 3.00 pcf, H9	15.48 + 3.16	10.69 + 1.49	3	12
nylon/nylon 62/38 fabric	15.52 + 0.19	11.99 + 0.36	2	8
southern yellow pine	15.56 + 0.12	10.91 + 0.86	3	12
polymethyl methacrylate	15.58 + 0.23	12.61 + 0.05	2	8
rayon/olefin 56/44 fabric	15.60 + 5.14	11.85 + 1.73	2	8
vinyl, expanded, fabric	15.64 + 0.95	7.69 + 0.48	2	8
polyaryl sulfone, 2	15.72 + 1.40	10.61 + 1.33	2	8
nylon/nylon 57/43 fabric	15.73 + 5.79	12.36 + 3.58	2	8
aromatic polyamide fabric, 3	15.74 + 2.13	13.37 + 1.38	3	12
excelsior	15.82 + 0.11	6.60 + 0.54	2	8
nitrile rubber, 2	15.85 + 0.97	9.50 + 0.16	3	12
polyvinylidene fluoride	15.86 + 2.74	6.50 + 0.11	2	8
hardboard	15.90 + 2.62	9.66 + 2.68	4	16
bisphenol A polycarbonate, 2	16.08 + 3.98	12.82 + 2.76	2	8
rayon/cotton 59/41 fabric	16.08 + 0.81	10.18 + 2.05	2	8
knock	16.15 + 0.47	7.40 + 2.05	2	8
polyurethane flexible foam, HR, FR, 2.90 pcf, H3	16.25 + 2.11	11.05 + 2.04	3	12

values given are mean ± standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY



Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
acetate/cotton/polyester 52/37/11 fabric	16.28 ± 4.69	11.65 ± 2.47	2	8
rayon fabric, 100%	16.30 ± 3.86	8.88 ± 1.31	2	8
olefin fabric, 100%	16.33 ± 5.90	7.72 ± 0.45	2	8
nylon fabric, 100%	16.33 ± 3.50	12.56 ± 1.21	2	8
cotton/polyester 63/35 fabric, FR	16.34 ± 4.07	9.88 ± 1.46	2	8
nylon 6/6				
cotton/rayon 69/31 fabric	16.34 ± 0.85	14.01 ± 0.13	2	8
polyvinyl chloride, 2	16.37 ± 3.54	11.85 ± 0.96	2	8
cotton/polyester 70/30 fabric	16.37 ± 0.57	5.95 ± 0.78	2	8
asphalt saturated organic felt, 15 lb	16.49 ± 1.90	9.04 ± 0.45	2	8
	16.52 ± 0.90	12.78	1	4
rayon/cotton 92/8 fabric	16.56 ± 4.56	12.77 ± 3.40	2	8
cotton/rayon 67/33 fabric	16.58 ± 3.01	9.38 ± 0.09	2	8
polyurethane flexible foam, 1.45 pcf, B1	16.60 ± 1.14	10.21 ± 0.86	2	8
nylon fabric, 100%	16.69 ± 0.06	11.69 ± 1.37	2	8
cotton fabric, 100%	16.78 ± 2.25	8.72 ± 1.31	4	16
polyvinyl chloride, 1	16.84 ± 0.93	12.69 ± 2.84	2	8
phenolphthalein polycarbonate	16.92 ± 0.13	14.15	1	4
rayon fabric, 100%	17.00 ± 7.13	8.59 ± 0.24	2	8
polyurethane flexible foam, FR, 1.50 pcf, C2	17.12 ± 1.72	12.37 ± 2.26	2	8
asphalt coated organic roof felt	17.20 ± 1.23	13.93	1	4
nylon fabric, brushed	17.22 ± 4.03	13.24 ± 2.81	2	8
polyurethane rigid foam, FR, 18.5 pcf	17.29 ± 0.96	12.12 ± 0.16	2	8
polychloroprene, 1	17.36 ± 2.34	13.45 ± 1.30	2	8
asphalt impregnated fiberboard sheathing	17.44 ± 2.05	10.99 ± 3.61	4	16
polyurethane flexible foam, FR, 1.20 pcf, A2	17.48 ± 0.64	12.50 ± 1.31	2	8
vinyl, expanded, fabric, FR	17.49 ± 1.07	7.62 ± 2.38	2	8
rayon fabric, 100%	17.60 ± 3.68	10.53 ± 0.16	2	8
ABS, 2	17.62 ± 4.77	13.52 ± 3.46	5	20
olefin fabric, 100%	17.74 ± 5.56	10.52 ± 0.15	2	8
rayon fabric, 100%	17.88 ± 3.25	10.33 ± 5.85	2	8

values given are mean ± standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY



Table 1. continued. Relative Toxicity Data Using USF Procedure B  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
medium density hardboard cotton/rayon/acetate 58/38/4 fabric polyurethane flexible foam, 1.20 pcf, A1 chipboard polyurethane flexible foam, 1.50 pcf, C1	17.87 + 3.42	9.69 + 0.95	4	16
	17.91 + 9.81	10.09 + 2.31	2	8
	18.21 + 1.57	12.78 + 0.45	2	8
	18.23 + 0.95	9.68 + 1.08	4	16
	18.28 + 0.91	11.12 + 1.79	2	8
FR cotton/FR rayon 50/50 fabric nylon fabric, 100% polyurethane flexible foam, FR, 1.45 pcf, B2 rayon fabric, 100% polyphenylene sulfide, 4	18.36 + 1.57	10.63 + 1.50	3	12
	18.52 + 5.62	15.51 + 5.67	2	8
	18.56 + 1.26	11.14 + 4.00	2	8
	18.61 + 3.80	9.22 + 0.23	2	8
	18.79 + 1.05	15.47	1	4
phenolic fabric, 100% nylon fabric, 100% ABS, 1 chlorosulfonated polyethylene, 2 rayon/cotton/nylon 70/28/2 fabric	18.81 + 4.84	12.92 + 3.22	4	16
	19.10 + 3.34	12.34 + 1.89	2	8
	19.30 + 4.25	11.35 + 1.32	2	8
	19.42 + 3.04	8.22 + 1.58	3	12
	19.43 + 2.61	11.14 + 7.58	2	8
olefin fabric, 100% coal tar saturated organic felt, 15 lb polyethylene, 2 rayon/acetate/cotton 43/35/22 fabric fiberboard soundstop	19.49 + 0.81	8.26 + 1.05	2	8
	19.84 + 1.82	14.40	1	4
	19.84 + 0.29	8.86 + 0.80	2	8
	19.87 + 1.43	8.90 + 0.82	2	8
	19.88 + 5.04	13.00 + 1.13	4	16
polyphenylene oxide, modified rayon/nylon 72/28 fabric asphalt saturated asbestos felt, 15 lb dead level asphalt polystyrene, 1	19.96 + 3.61	8.65 + 2.29	2	8
	19.96 + 0.40	14.52 + 0.88	2	8
	19.99 + 3.01	14.77	1	4
	20.02 + 0.95	14.73	1	4
	20.03 + 2.97	15.18 + 0.76	2	8
polychloroprene, 3 polyurethane flexible foam, FR, 1.20 pcf, A3 polychloroprene flexible foam, 1 nitrile rubber, 1 polyvinyl fluoride	20.13 + 1.09	15.70 + 0.92	2	8
	20.13 + 1.06	13.58 + 2.00	2	8
	20.23 + 4.12	14.57 + 1.55	5	20
	20.24 + 1.09	13.84 + 1.74	3	12
	20.50 + 2.05	16.94 + 2.39	2	8

values given are mean + standard deviation

Table 1. continued. Relative Toxicity Data Using USF Procedure B:  
200-800°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
fluorene polycarbonate	20.52 ± 1.96	16.77	1	4
cotton fabric, FR, 3	20.55 ± 2.01	8.92 ± 4.91	2	8
cellulose fiberboard, core board	20.58 ± 4.38	9.91 ± 5.24	4	16
steep asphalt	20.60 ± 0.93	11.58	1	4
ethylene propylene diene terpolymer, 1	20.66 ± 0.31	10.82 ± 3.24	3	12
isocyanurate foam, urethane modified, glass fiber, 1	20.71 ± 3.93	17.81 ± 3.27	2	8
ethylene propylene diene terpolymer, 2	20.71 ± 0.98	15.12 ± 1.90	2	8
acrylonitrile rubber, 3	21.29 ± 2.52	14.03 ± 0.96	3	12
rayon/phenolic 50/50 fabric	21.43 ± 6.18	15.39 ± 1.95	3	12
chlorinated polyvinyl chloride, 1	21.76 ± 4.22	6.29 ± 0.60	3	12
bisphenol A polycarbonate, FDA grade, reference	22.08 ± 2.21	15.29 ± 1.93	20	80
polyisoprene, natural rubber	22.13 ± 1.73	15.35 ± 4.32	3	12
chlorosulfonated polyethylene, 1	22.35 ± 3.44	17.06 ± 2.61	4	16
pitch asphalt	22.41 ± 0.30	17.67	1	4
polyethylene, 3	22.60 ± 0.62	16.68 ± 2.23	2	8
isocyanurate foam, urethane modified, glass fiber, 2	22.66 ± 3.27	20.00 ± 4.31	2	8
chlorinated polyvinyl chloride, 2	22.74 ± 6.22	9.00	1	4
nylon fabric, 100%, treated	22.74 ± 2.62	10.49 ± 3.14	4	16
bisphenol A polycarbonate, 1	23.04 ± 5.25	16.02 ± 1.86	2	8
polychloroprene, 4	23.16 ± 2.04	10.95 ± 5.21	3	12
polyurethane rigid foam, FR, Q2	23.52 ± 2.04	17.58 ± 4.59	3	12
nylon fabric, 100%	23.75 ± 7.42	11.84 ± 2.35	2	8
styrene butadiene rubber (SBR)	24.11 ± 2.08	15.73 ± 6.25	3	12
fiberglass/nylon fabric	24.60 ± 4.50	14.82 ± 3.45	2	8
chlorinated polyethylene rubber, 1	24.80 ± 0.10	7.50 ± 1.10	2	8
polychloroprene flexible foam, 2	25.59 ± 3.81	12.52 ± 3.87	6	24
polystyrene, 2	26.16 ± 0.12	19.04 ± 0.39	2	8
chlorinated polyethylene rubber, 2	27.35 ± 4.21	11.11 ± 6.21	2	8
polychloroprene, 2	27.53 ± 4.71	14.48 ± 8.76	3	12
high temperature insulation, perlited	n.d.	n.i.	1	4
quartz	n.d.	n.i.	4	16

values given are mean ± standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY

Table 2. Relative Toxicity Data Using USF Procedure D  
200-800°C rising temperature, 40°C/min, 48 ml/sec air flow

Material	Time, min, to		Number of	
	Death	Incapacitation	Tests	Animals
wool fabric	6.68 ± 0.47	4.85 ± 0.64	2	8
polyurethane flexible foam, F3	6.95 ± 0.66	5.35 ± 0.78	5	20
polyethylene	7.08 ± 0.30	5.91 ± 0.16	2	8
Douglas fir	8.98 ± 1.94	7.28 ± 1.45	2	8
polyurethane rigid foam, Q	8.98 ± 0.71	4.41 ± 0.13	2	8
nylon 6	9.05 ± 0.23	6.82	1	4
polyphenylene sulfide	9.74 ± 2.60	8.96 ± 2.06	2	8
polybismaleimide	10.17 ± 0.12	8.42	1	4
chlorinated polyvinyl chloride	10.86 ± 3.58	8.21 ± 2.77	2	8
polyether sulfone, 200-P	11.45 ± 0.86	10.02 ± 0.85	2	8
bisphenol A polycarbonate, 1	11.50 ± 0.91	9.83	1	4
polychloroprene flexible foam	12.00 ± 3.37	10.34 ± 2.64	3	12
polyaryl sulfone	12.03 ± 1.67	9.81 ± 0.84	3	12
bisphenol A polycarbonate, 2	12.59 ± 0.12	10.50	1	4
polyether sulfone, 300-P, glass	12.77 ± 0.62	10.75 ± 1.41	2	8
polychloroprene flexible foam	14.38 ± 0.19	11.86 ± 0.16	2	8
polyether sulfone, 212-P	15.47 ± 4.20	11.92 ± 2.05	3	12
hemlock, untreated	n.d.	9.15	1	4
red oak	n.d.	11.08 ± 0.80	2	8

values given are mean ± standard deviation



Table 3. Relative Toxicity Data Using USF Procedure F:  
800°C fixed temperature, no forced air flow

Material	Time, min, to		Tests	Number of Animals
	Death	Incapacitation		
polyphenylene sulfide	2.58 ± 0.41	2.00 ± 0.24	2	8
wool/nylon 86/14 fabric	3.04 ± 0.57	1.36 ± 0.01	2	8
polyether sulfone, 200-P	4.27 ± 0.48	2.97 ± 0.66	3	12
acrylonitrile rubber	4.34 ± 0.18	2.11 ± 0.13	3	12
polyaryl sulfone	4.34 ± 0.41	2.99 ± 0.62	2	8
wool/spandex 99/1 fabric	4.38 ± 1.59	2.11 ± 0.55	2	8
wool fabric, 100%, reference	4.67 ± 1.00	2.21 ± 0.52	3	12
yellow birch	5.31 ± 0.99	2.99 ± 0.52	4	16
polyether sulfone, 212-P	5.50 ± 0.28	3.00 ± 0.81	2	8
southern yellow pine	5.54 ± 1.15	2.83 ± 0.58	4	16
rayon fabric, 100%	5.95 ± 0.03	3.62 ± 0.35	2	8
red oak	6.06 ± 0.40	2.85 ± 0.99	5	20
aspen poplar	6.09 ± 0.35	2.74 ± 0.83	4	16
western red cedar	6.14 ± 1.03	3.53 ± 1.45	5	20
polyester fabric, 100%	6.15 ± 1.72	2.75 ± 1.73	3	12
eastern white pine	6.24 ± 1.36	3.12 ± 0.87	4	16
polyphenyl sulfone	6.29 ± 0.01	3.87 ± 0.33	2	8
western hemlock	6.41 ± 1.12	3.37 ± 0.95	4	16
beech	6.61 ± 1.24	3.30 ± 0.37	5	20
Douglas fir	7.04 ± 2.47	4.33 ± 1.29	3	12
cotton fabric, 100%	7.56 ± 0.90	4.16 ± 0.23	2	8
polymethyl methacrylate	7.74 ± 1.79	2.88 ± 0.71	2	8
acrylonitrile-butadiene-styrene (ABS)	9.51 ± 1.09	3.09 ± 1.57	4	16
bisphenol A polycarbonate, FDA grade, reference	9.56 ± 2.09	5.31 ± 0.95	6	24
chlorosulfonated polyethylene	9.58 ± 2.08	7.09 ± 2.87	3	12

values given are mean ± standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY



Table 3. continued. Relative Toxicity Data Using USF Procedure F:  
800°C fixed temperature, no forced air flow

Material	Time, min. to		Number of Tests	Animals
	Death	Incapacitation		
polyethylene, 2	9.73 + 1.93	6.84 + 1.18	2	8
ethylene propylene diene terpolymer (EPDM)	10.61 + 0.88	7.54 + 0.41	3	12
polypropylene fabric, 100%	11.22 + 0.31	7.64 + 0.25	2	8
polypropylene fabric, 100%	11.45 + 1.67	3.24 + 0.11	2	8
polyethylene, 3	11.72 + 0.57	3.57 + 1.00	2	8
polyisoprene, natural rubber	11.75 + 0.72	8.31 + 0.69	3	12
polychloroprene	12.20 + 0.43	9.52 + 0.90	3	12
polyurethane rigid foam, Q	12.58 + 0.27	10.22 + 1.09	2	8
rayon fabric, 100%	13.58 + 4.62	6.70 + 0.68	2	8
styrene-butadiene rubber (SBR)	13.82 + 1.70	9.55 + 0.28	3	12
chlorinated polyvinyl chloride	14.90 + 0.04	2.13 + 0.49	2	8
nylon fabric, 100%	15.03 + 4.83	3.92 + 0.11	2	8
polyvinyl chloride	15.33 + 2.02	1.94 + 0.05	2	8
polystyrene, 2	19.90 + 1.37	12.48 + 1.45	2	8
polystyrene, 1	21.84 + 6.61	5.99 + 4.17	3	12
polychloroprene flexible foam	25.44 + 2.92	11.19 + 3.34	2	8

values given are mean + standard deviation

Table 4. Relative Toxicity Data Using USF Procedure G  
800°C fixed temperature, 16 ml/sec air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
wool/spandex 99/1 fabric	2.39 ± 0.03	0.98 ± 0.02	2	8
wool fabric, 100%, reference	2.66 ± 0.05	1.42 ± 0.25	3	12
wool/nylon 86/14 fabric	3.70 ± 2.61	1.24 ± 0.13	2	8
ABS	3.80 ± 1.53	1.69 ± 0.05	2	8
rayon fabric, 100%	4.60 ± 1.59	2.38 ± 1.28	2	8
polyurethane rigid foam, FR, Q	4.98 ± 0.48	2.28 ± 0.54	3	12
nylon fabric, 100%	5.00 ± 2.94	1.86 ± 0.52	2	8
cotton fabric, 100%	5.44 ± 0.52	2.42 ± 0.66	2	8
bisphenol A polycarbonate, FDA grade, reference	5.99 ± 0.69	2.83 ± 0.52	3	12
polyester fabric, 100%	6.21 ± 0.66	2.19 ± 1.05	2	8
rayon fabric, 100%	6.24 ± 0.77	1.72 ± 0.64	2	8
polyolefin fabric, 100%	10.10 ± 2.45	3.94 ± 3.56	2	8
polychloroprene flexible foam	11.40 ± 4.66	7.85 ± 2.66	2	8
polyethylene	n.d.	2.91 ± 1.32	2	8
polystyrene	n.d.	3.88 ± 2.27	3	12
polyolefin fabric, 100%	n.d.	18.73	2	8

values given are mean ± standard deviation

Table 5. Relative Toxicity Data Using USF Procedure H  
800°C fixed temperature, 48 ml/sec air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
wool/spandex 99/1 fabric	2.13 + 0.08	1.32 + 0.30	2	8
wool fabric, 100%, reference	2.44 + 0.74	1.50 + 0.23	3	12
wool/nylon 86/14 fabric	2.55 + 0.99	1.08 + 0.36	2	8
ABS	3.47 + 0.39	1.47 + 0.49	2	8
rayon fabric, 100%	4.48 + 3.05	1.79 + 1.56	3	12
polyester fabric, 100%	5.02 + 0.74	2.41 + 0.69	2	8
polyurethane rigid foam, Q	5.90 + 2.02	2.02 + 0.42	3	12
nylon fabric, 100%	6.01 + 2.94	2.79 + 0.48	2	8
cotton fabric, 100%	6.63 + 2.59	3.85 + 3.51	2	8
bisphenol A polycarbonate, FDA grade, reference	6.71 + 0.19	2.76 + 0.76	2	8
polyolefin fabric, 100%	6.84 + 1.75	2.64 + 0.72	2	8
rayon fabric, 100%	7.58 + 0.98	3.81 + 1.43	2	8
polyolefin fabric, 100%	8.27 + 0.04	4.62 + 1.41	2	8
polychloroprene flexible foam	21.06 + 5.67	12.98 + 4.15	2	8
polyethylene	n.d.	5.11 + 1.07	2	8
polystyrene	n.d.	6.11 + 2.85	2	8

values given are mean + standard deviation

ORIGINAL PAGE IS  
OF POOR QUALITY



Table 6. Relative Toxicity Data Using USF Procedure E  
600°C fixed temperature, no forced air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
wool/spandex 99/1 fabric	4.45 + 0.27	2.60 + 0.75	2	8
polyester fabric, 100%	9.02 + 0.60	5.44 + 1.32	2	8
wool fabric, 100%, reference	9.76 + 3.75	3.20 + 0.21	2	8
wool/nylon 86/14 fabric	10.13 + 3.91	2.79 + 0.30	3	12
rayon fabric, 100%	10.96 + 0.33	3.98 + 2.00	2	8
polyethylene	16.62 + 2.00	9.95 + 0.04	2	8
ABS	18.52 + 5.08	5.83 + 2.10	2	8
cotton fabric, 100%	19.60 + 2.28	11.38 + 0.01	2	8
polyolefin fabric, 100%	19.52 + 0.70	5.94 + 1.17	2	8
polyolefin fabric, 100%	21.26 + 3.73	13.53 + 4.15	2	8
bisphenol A polycarbonate, FDA grade, reference	21.70 + 0.65	10.49 + 0.01	2	8
rayon fabric, 100%	24.60 + 6.05	16.25	1	4
nylon fabric, 100%	25.13 + 0.41	11.03 + 8.82	2	8
polystyrene	25.96 + 0.68	10.34 + 6.70	2	8
polychloroprene flexible foam	n.d.	n.i.	2	8

values given are mean + standard deviation



Table 7. Relative Toxicity Data Using USF Procedure I  
600°C fixed temperature, 16 ml/sec air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
wool/spandex 99/1 fabric	2.78 + 0.30	1.85 + 0.20	2	8
wool/nylon 86/14 fabric	3.47 + 0.17	1.82 + 0.25	2	8
wool fabric, 100%, reference	4.08 + 0.58	1.85 + 0.55	3	12
ABS	4.53 + 0.16	2.84 + 0.06	2	8
cotton fabric, 100%	4.85 + 0.21	2.94 + 0.34	2	8
rayon fabric, 100%	5.35 + 1.54	2.70 + 0.04	2	8
polyolefin fabric, 100%	5.44 + 1.18	2.72 + 0.35	2	8
rayon fabric, 100%	5.50 + 0.24	4.30	1	4
polyester fabric, 100%	5.88 + 0.51	3.49 + 0.01	2	8
bisphenol A polycarbonate, FDA grade, reference	7.40 + 0.98	4.63 + 0.16	2	8
nylon fabric, 100%	7.97 + 2.00	2.96 + 0.67	3	12
polychloroprene flexible foam	8.10 + 1.94	3.11 + 0.13	2	8
polyethylene	8.80	5.31 + 0.52	2	8
polyolefin fabric, 100%	10.24 + 0.36	4.97 + 0.71	2	8
polystyrene	11.95 + 1.43	4.09 + 0.86	2	8

values given are mean + standard deviation

Table 8. Relative Toxicity Data Using USF Procedure J  
600°C fixed temperature, 48 ml/sec air flow

Material	Time, min, to		Number of Tests	Animals
	Death	Incapacitation		
wool/spandex 99/1 fabric	3.20 + 0.07	2.53 + 0.85	2	8
wool fabric, 100%, reference	4.01 + 0.95	1.89 + 0.61	3	12
cotton fabric, 100%	4.17 + 0.62	2.49 + 0.05	3	12
rayon fabric, 100%	5.16 + 0.76	2.37 + 0.63	3	12
polyester fabric, 100%	5.50 + 0.48	3.24 + 1.31	2	8
ABS	5.96 + 2.61	2.60 + 0.04	2	8
polystyrene	7.04 + 1.48	3.08 + 0.25	2	8
nylon fabric, 100%	7.77 + 2.67	2.34 + 0.60	3	12
polyolefin fabric, 100%	8.36 + 0.68	3.78 + 2.13	2	8
wool/nylon 86/14 fabric	8.70 + 3.39	1.80 + 0.67	2	8
polyethylene	9.69 + 1.15	4.08 + 3.40	2	8
bisphenol A polycarbonate, FDA grade, reference	9.88 + 2.43	7.66 + 1.54	2	8
rayon fabric, 100%	13.18 + 4.18	6.42	1	4
polychloroprene flexible foam	15.13 + 2.29	10.52 + 4.03	2	8
polyolefin fabric, 100%	17.48 + 5.48	7.15	2	8

values given are mean + standard deviation

Table 9. Relative Toxicity Data Using USF Procedure A  
200-600°C rising temperature, 40°C/min, no forced air flow

Material	Time, min, to		Number of Tests Animals
	Death	Incapacitation	
wool fabric	5.70 + 0.52	4.33 ± 0.34	3 12
hemlock	11.91 + 1.19	9.23	1 4
red oak	12.86 + 1.92	9.02 + 0.11	2 8
nylon 6	13.70 + 0.43	12.50	1 4
polyethylene	14.50 ± 0.81	11.65 ± 1.31	2 8
Douglas fir	14.79 + 0.49	9.98 + 0.28	2 8
chlorinated polyvinyl chloride	16.44 ± 2.91	9.07 ± 0.14	2 8
polychloroprene flexible foam	28.39 ± 5.13	19.55	3 12
polybismaleimide	29.09 ± 2.36	19.33	1 4
polyphenylene sulfide	29.29 ± 0.14	26.83	2 8
bisphenol A polycarbonate, 2	31.66 ± 2.08	23.80 ± 2.30	2 8
bisphenol A polycarbonate, 1	33.17	22.55	1 4
polyaryl sulfone	n.d.	n.i.	2 8
polyether sulfone, 200-P	n.d.	n.i.	2 8
polyether sulfone, 212-P	n.d.	n.i.	2 8
polyether sulfone, 300-P, glass fabric	n.d.	n.i.	1 4

values given are mean ± standard deviation

Table 10. Relative Toxicity Data Using USF Procedure C  
200-800°C rising temperature, 20°C/min, 16 ml/sec air flow

Material	Time, min, to		Number of Tests Animals
	Death	Incapacitation	
wool fabric	4.94 + 0.04	3.58 + 0.43	2 8
polyurethane flexible foam, F3	7.34 + 0.89	5.53 ± 0.51	4 16
polychloroprene flexible foam	10.32 ± 0.73	7.35 ± 0.55	3 12

values given are mean ± standard deviation



ORIGINAL PAGE IS  
OF POOR QUALITY

1. Report No. NASA TM-78,462	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle TOXICITY OF MATERIALS IN FIRE SITUATIONS: LABORATORY DATA OBTAINED AT THE UNIVERSITY OF SAN FRANCISCO	5. Report Date	6. Performing Organization Code
7. Author(s) Carlos J. Hilado,* Colleen J. Casey,* Demetrius A. Kourtides, and John A. Parker	8. Performing Organization Report No. A-7304	10. Work Unit No. 505-08-21
9. Performing Organization Name and Address *University of San Francisco, San Francisco, CA 94117 and NASA Ames Research Center, Moffett Field, CA 94035	11. Contract or Grant No.	13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code	
15. Supplementary Notes		
16. Abstract <p>Toxicity test data on materials evaluated at the University of San Francisco are presented. Approximately 300 materials have been evaluated using a specific set of test conditions. Data obtained using ten different sets of test conditions are presented.</p>		
17. Key Words (Suggested by Author(s)) Toxicity	18. Distribution Statement Unlimited  STAR Category - 23	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 26
		22. Price* \$1.00